ENGINEERING REPORT

REPORT NO. 2375

DATE Nov. 7, 1978

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The Bendix Corporation — Electrical Components Division — Sidney, New York

TITLE

EVALUATION OF BRUSH CONTACT CONNECTORS WITH SIMULATED DAMAGE OF BRUSH CONTACT BRISTLES

TYPE

Evaluation

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PREPARED	APPROVED	APPROVED	APPROVED
Robert N. Waghorn	John W. Long	R. E. Nelson	E. A. Klaus
DATE 11.14.78	DATE 11/14/78	DATE 11-14-78	DATE 11/14/78

SC654A

I. PURPOSE

The purpose of the testing was to determine the effects of damaged or missing brush contact bristles on the performance of brush contact connectors.

II. CONCLUSIONS

1. The initial mating force for the connector pair containing the intentionally damaged bristles was 37 pounds, or averaged 3.9 ounces/contact pair. The high forces were anticipated because of the opposition that the bent bristles would create during wire bundle engagement. The initial high force was also due, in part, to the alignment method of rigidly mounted connectors. Unmating and mating forces are normally measured on mated connectors that have been fixtured in a fully mated condition.

2. Reducing the number of bristles in motherboard contacts increased the contact resistance in a linear relationship having a slope of approximately .6 milliohms per strand.

3. Deliberately bending or damaging one bristle in either motherboard or daughterboard contacts produced a minimal change in contact resistance.

4. Contact resistance measurements were highest after the initial mating cycle. After 250 cycles, the values were reduced and remained stable throughout the balance of the 1000 cycles of durability.

5. After the first mating-unmating cycle, some skiving of the plastic in the motherboard contact cavities was observed.

6. Visual examination throughout the test sequence evidenced some deflection of the deliberately bent bristles.

7. The latter two conditions remained relatively unchanged throughout the 1000 durability cycles. Overall, the connectors maintained a good visual appearance during the entire test sequence.

III. RECOMMENDATIONS

It is recommended that the mating and unmating forces be considered with regard to the fact that two thirds of the contact mating pairs were physically modified. It should also be noted that the mating and unmating force measurements were not performed from the normally mated condition which establishes initial alignment. Both mating connector halves were rigidly mounted which would oppose the natural alignment of the connectors.

IV. ACTION TAKEN

None

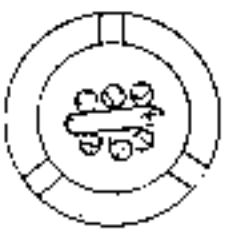
V. DETAILED REPORT

A. Sample Preparation

The following components were submitted for assembly and evaluation:

2 pcs 10-502542-150 Motherboard (MB) Connector Moldings
2 pcs 10-502562-150 Daughterboard (DB) Connector Moldings
300 pcs 10-502402-31 Male Brush Wire Contacts (MB)
150 pcs 10-502400-121 Female Brush Wire Contacts (DB)
150 pcs 10-502400-221 Female Brush Wire Contacts (DB)

Prior to the installation of the contacts into their respective connector moldings, the contacts were modified as shown in Table I. To obtain 6 or 5 wires, one or two bristles were bent out from the bundle at the holder surface and flexed back and forth through an approximate arc of 90° until the strand fractured and broke off. Bent wires were bent through the bristle bunch as shown below.



After contact insertion and bending of the daughterboard tails was accomplished, circuit boards were soldered to each connector half.

TABLE I
CONDITION OF BRUSH WIRES IN SAMPLE CONNECTORS

Sample Connector		Contact Location Identification A1-A25 B1-B25	A26-A50 B26-B50	A51-A75 B51-B75
1	MB	5 Wires	6 Wires	7 Wires
	DB	7 Wires	7 Wires	7 Wires
2	MB	7 Wires	7 Wires 1 Bent	7 Wires
	DB	7 Wires 1 Bent	7 Wires	7 Wires

B. Test Sequence

Photographs of the contacts displaying the intentional bristle damage were taken prior to the initial mating. These photographs are in Appendix B as Figures 1, 2, 3 and 4. Figures 1 and 2 are representative cavities of #2 motherboard connector, cavities A26-A50 and B26-B50. Figures 3 and 4 are representative cavities of #2 daughterboard connector, cavities A1-A25 and B1-B25.

1. Mating Force - The initial mating force measurement of each connector pair was performed on the Instron Model 1122 force tester. The special motherboard holding fixture was mounted on a ball bearing table attached to the load cell. The L-34119-58 parallel clamping fixture to hold daughterboard connectors was mounted to the crosshead. The connectors were positioned for mating and mated at a rate of 0.100 inch/minute. The mating was stopped when it was apparent that further mating would result in molding to molding interference. The initial mating forces were recorded on Data Sheet 1 of Appendix A. Normally, fixturing for this test is accomplished with the connectors in their fully mated condition. The force to completely separate the connectors is measured first and then the connectors are remated within 0.010 inch of the original fully mated condition.

2. Contact Resistance - Contact resistance measurements were performed on each mating pair of contacts in both mated connector pairs after the initial mating. The Keithly Model 503 Milliohmmeter was used in conjunction with a voltage divider, digital voltmeter and a paper tape punch to record the data. The paper tape punch data was reduced and analyzed via the Hewlett-Packard (H-P) 9820 calculator, printed on tape and placed on data sheets 4, 5 and 6 of Appendix A. All values were less than 11.5 milliohms, except for six measurements in Sample #1, Row B 1-25. These six values were less than 13.6 milliohms.

3. Unmating Forces - Initial unmating forces were performed on the Instron 1122 using the same fixturing as for mating forces. The fully mated connectors were separated at a rate of 0.100 inch/minute. The unmating forces are recorded on Data Sheet 1 in Appendix A.

4. Visual Examination - Visual examination at 12X magnification after the initial unmating did not reveal any noticeable contact damage in addition to the deliberate simulated damage at the onset of the test. There was minor skiving of molding material in the contact retention cavities of the #2 motherboard connector. These conditions are specifically noted on Data Sheet 3 in Appendix A. Photographs of some of the representative cavities verify that there was no additional damage incurred. See Figures 4, 5, 6 and 7 in Appendix B.

5. Durability (10 Cycles) - Each connector pair was mated and unmated by hand an additional nine times. The daughterboard connector was rigidly mounted while the motherboard was mated with it.

6. Unmating and Mating Forces - After ten cycles of durability by hand, the unmating and mating force measurements were performed starting with the connectors in the mated condition to assure alignment. The same fixtures and rate application were used as initially. The values are recorded on Data Sheet 1 in Appendix A. The unmating force increased slightly from the initial, but the mating force was reduced approximately fifty percent.

7. Visual Examination - There were some compounded discrepancies noted after ten cycles of durability. The No. 2 Motherboard connector displayed bending of one bristle in three contacts that were deliberately damaged initially. The visual examination was performed at 12X magnification and the comments are recorded on Data Sheet 2 of Appendix A.

8. Durability (250 Cycles) - Each pair of connectors was mated and unmated a total of 250 cycles by hand. The mating and unmating was relatively easy, but it was more difficult with the #2 sample where two thirds of the mated contact population had some type of intentional bristle damage.

9. Unmating and Mating Forces - After 250 cycles of durability, the mated connectors were fixtured on the Instron and unmated mated at a rate of 0.100 inch/minute. The forces required to unmate and mate them increased from those recorded after 10 cycles of durability. Compare the forces recorded on Data Sheet 1 of Appendix A.

10. Contact Resistance - Contact resistance was performed as described in Paragraph No. 2 above, after the 250 cycles of durability conditioning. All values were less than 11.4 milliohms. Individual measurements and statistical analysis are recorded on Data Sheets 7, 8 and 9 in Appendix A. The average resistance of each contact pair-group displayed a decrease of 0.2 milliohms, except Row B control contacts (7 bristles) in #2 connector which increased 0.3 milliohms.

11. Visual Examination - A visual examination of the connectors at 12X magnification revealed no apparent change in either half of the No. 1 sample or the daughterboard half of Sample No. 2. No. 2 motherboard had three additional bristles that were bent to some degree and some minor skiving of the plastic was noted.

12. Sequence Tests (500 Cycles) - Each pair of connectors was mated and unmated by hand an additional 250 times for a total of 500 cycles of durability.

The unmating and mating forces were measured as described in Paragraph No. 9 above. The change in forces of the No. 1 sample were negligible. The forces for the No. 2 sample were reduced. The force values are recorded on Data Sheet 1 in Appendix A and may be compared with other force values.

The contact resistance of each mated contact pair in both connectors was measured and recorded as described in

Paragraph No. 2 above. The average resistance of two groups increased 0.1 milliohms, two were unchanged and eight had a decrease of 0.1 to 0.7 milliohms. The contact resistance values were all less than 11.4 milliohms after 500 cycles of durability and are recorded on Data Sheets 10, 11 and 12 in Appendix A.

A visual examination at 12X magnification revealed minor skiving of the plastic molding in two additional contact cavities in each motherboard connector, as noted on Data Sheet 2 in Appendix A.

(750 Cycles) Each mating pair of connectors was subjected to a total of 750 cycles of durability by hand. The unmating and mating forces were measured as described in Paragraph 9 above. The maximum increase in force from the measurements after 500 cycles of durability was 1.7 pounds. The values are recorded on Data Sheet 1 in Appendix A.

The contact resistance measurements were performed as before and are recorded on Data Sheets 13, 14, and 15 in Appendix A. The average resistance change for any of the twelve contact groups from 500 to 750 cycles of durability was 0.2 milliohms. Four groups were unchanged and the other eight groups varied 0.1 milliohms.

Visual examination at 12X magnification did not reveal any discrepancies in addition to those noted after 500 cycles of durability.

(1000 Cycles) The mating connector pairs were each mated and unmated by hand an additional 250 times for a total of 1000 cycles of durability. The unmating and mating forces were measured as described in Paragraph 9 above. The maximum change in force from 750 cycles of durability was the mating force of the No. 2 sample, an increase of 1.5 pounds. The other force value changes were negligible as noted on Data Sheet 1 in Appendix A.

The contact resistance test was performed as described in Paragraph 2 above and the values were recorded on Data Sheets 16, 17 and 18 in Appendix A. The maximum average resistance change as a result of an additional 250 cycles of durability for six contact groups was 0.2 milliohms. Six groups did not display a change. All values were 11.4 milliohms or less.

The visual examination was performed at 12X magnification. The results are recorded on Data Sheet 3 and may be compared with the initial discrepancy notations. The No. 1 mating halves did not display any significant physical changes. The No. 2 motherboard connector had four bristles that were conspicuously more bent over than when deliberately formed that way for the test. One other bristle in A49 was also bent, but the deliberately bent bristle did not display additional deflection.

Photographs of the No. 2 motherboard, Row A & B 1-25 and No. 2 daughterboard, Rows A & B 26-50 were made to document the changes in bristle bunch configuration and damage. These are represented in Figures 9, 10, 11 and 12 of Appendix B.

A summary of contact resistance mean values for each group throughout the test sequence appears in Table II.

VI. REFERENCES

EWCM G997
Contract #71366-A
CLT 4924
ECL0592-33 through -36
ECL0592A-35 through -51

TABLE II

SUMMARY OF CONTACT RESISTANCE MEASUREMENTS
(MEAN VALUES, N = 25)

Connector #1, Row A

No. of Bristles in MB Contacts	Number of Durability Cycles Completed				
	Initial	250	500	750	1000
5	8.3	7.9	8.0	7.9	8.0
6	7.9	7.3	7.3	7.4	7.4
7	8.0	7.0	7.1	6.9	6.7

Connector #1, Row B

No. of Bristles in MB Contacts	Number of Durability Cycles Completed				
	Initial	250	500	750	1000
5	10.3	9.6	9.6	9.5	9.5
6	9.1	8.8	8.7	8.7	8.7
7	8.7	9.0	8.3	8.3	8.1

Connector #2, Row A

	Number of Durability Cycles Completed				
	Initial	250	500	750	1000
MB Contacts Damaged	7.8	7.3	7.2	7.2	7.2
DB Contacts Damaged	8.3	7.4	7.1	7.1	7.1
Control	7.2	7.0	6.9	7.1	7.0

Connector #2, Row B

	Number of Durability Cycles Completed				
	Initial	250	500	750	1000
MB Contacts Damaged	9.4	8.8	8.7	8.8	8.7
DB Contacts Damaged	9.6	8.6	8.4	8.3	8.4
Control	8.6	8.4	8.3	8.4	8.4

APPENDIX A

Data Sheets

LABORATORY DATA SHEET

TEST	Connector Mating & Unmating Forces
DATE OF TESTS	As Listed
REPORT NUMBER	2315
TEST SPECIMEN (S)	10-502562-150 MB (Mother Board) 10-502562-150 DB (Daughterboard)
TEMP.	
R.H.	
ECL	0592A-38A
LT.	4924
SPEC.	
PARA.	
TEST EQUIPMENT	Instron Model 1122 P.C. 2103
CAL DATE	5.16.78
DUE DATE	2.15.79
SPEC. LIMITS	
TEST CONDITIONS	Room Ambient Crosshead Speed 0.100 inch/min. L-34119-58 Holding Fixtures

Sample	Date	Temp R.H	Cycle	Mating Force	Unmating Force	Remarks
1	10.19.78	73F 45%	Initial	21 lbs		1 Good mating
2	10.19.78	73F 45%	Initial	37 lbs		2 The parallel clamping bars slipped on the DB PCB at the grounds. Recorded [illegible] was [illegible] the 5th [illegible] does not represent the full mating force, but only the slippage force. There was a space between the connectors at this end, indicating a not "fully" mated condition.
1						
1	10.31.78	82F 32%	Initial		4.1 lbs	
2	10.31.78	82F 32%	Initial		8 lbs	
1	11.1.78	74F 41%	10th	10.7 lbs	8.4 lbs	
2	11.1.78	74F 41%	10th	16.7 lbs	11.0 lbs	
1	11.1.78	74F 41%	250th	18.0 lbs	10.0 lbs	
2	11.1.78	74F 41%	250th	22.5 lbs	13.8 lbs	
1	11.1.78	79F 26%	500th	11.0 lbs	9.5 lbs	
2	11.1.78	79F 26%	500th	18.0 lbs	11.0 lbs	
1	11.2.78	80F 26%	750th	11.5 lbs	10.1 lbs	
2	11.2.78	80F 26%	750th	16.5 lbs	12.7 lbs	
1	11.3.78	74F 36%	1000th	11.5 lbs	10.5 lbs	
2	11.3.78	74F 36%	1000th	18.0 lbs	12.5 lbs	

REF. EWDM 6997
ECL0592-35, -34, -36

Bendix Electrical Components Division
Sidney, New York 13838

TESTED BY T.R. Baird (?), R.D. Wagner (?)
APPROVED BY
WITNESSED BY

72-354-2

LABORATORY DATA SHEET

TEST: VISUAL EXAMINATION			DATE OF TESTS: 11-1-78	REPORT NUMBER: 2375
TEST SPECIMEN (S): 10-502542-150 MB (MOTHERBOARD)			TEMP: 74°F RH: 41%	ECL0592A-41 SHT.
10-502562-150 DB (DAUGHTERBOARD)		LT. 4324	SPEC.	PARA
TEST EQUIPMENT: MODEL M5-97635 WILD MICROSCOPE E-4722	CAL DATE: N/A	DUE DATE: N/A	SPEC LIMITS	
			TEST CONDITIONS: ROOM AMBIENT. 12X MAGNIFICATION.	

74°F 41%

SAMPLE #1 AFTER 10TH UNMATING CYCLE. ONLY ADDITIONAL DISCREPANCIES.

NONE, ONLY CAVITY 35, A NO. MB DISPLAYED SKIVING OF 2 RETENTION TINES AND POSITIONED CONTACT TOWARD CAVITY WALL AS INITIALLY.

SAMPLE #2 MB AFTER 10TH UNMATING CYCLE

A16 1 WIRE BENT OVER
B26 1 " PARTIALLY BENT OVER
B49 1 " BENT OVER

} OK INITIALLY AFTER 1 MATING, UNMATING

74°F 41%

SAMPLE #1 NO CHANGE OF EITHER HALF AFTER 250 CYCLES OF DURABILITY.

SAMPLE #2 MB - ADDITIONAL DISCREPANCIES AFTER 250 CYCLES OF DURABILITY.

A28 SKIVING OF CAVITY - MINOR
A49 2 BRISTLES DAMAGED & MINOR SKIVING OF CAVITY
A45 1 BRISTLE BENT OVER.

#2 DB NO ADDITIONAL DAMAGE.

11-2-78 74°F 28%

SAMPLE #1 DB - NO CHANGE AFTER 500 CYCLES OF DURABILITY.
MB - ADDITIONAL - A1 SKIVING, B74 SKIVING

SAMPLE #2 DB - NO CHANGE AFTER 500 CYCLES OF DURABILITY.
MB - ADDITIONAL - B35 & B49 MINOR SKIVING.

11-3-78 74°F 36% AFTER 750 CYCLES OF DURABILITY.

SAMPLE #1	DB	NO CHANGE AFTER 750 CYCLES OF DURABILITY.
	MB	" " " " " " " "
SAMPLE #2	DB	" " " " " " " "
#2	MB	" " " " " " " "

REF EWDM 6991
ECL0592-35 & -36.

Bendix Electrical Components Division
Sidney, New York 13838

TESTED BY T.R. BAIRD
R.D. WAGNER
APPROVED BY
WITNESSED BY

LABORATORY DATA SHEET

TEST: VISUAL EXAMINATION - INITIAL & 1000™ UNMATING			DATE OF TESTS: 11-1-78 11-4-78	REPORT NUMBER: 2375
TEST SPECIMEN (S): 10-502562-150 MB (MOTHERBOARD)			TEMP: 74° 82°F / RH: 41% 34%	ECL: 0592A-51 EN:
10-502562-150 DB (DAUGHTER BOARD)		LT 4924	SPEC.	PARA
TEST EQUIPMENT: MODEL M5-97635 WILD MICROSCOPE F4722	CAL DATE: N/A	DUE DATE: N/A	SPEC LIMITS	
			TEST CONDITIONS: ROOM AMBIENT. 12 X MAGNIFICATION. R. GRANEY OF IBM VISUALED AFTER 1000 CYCLES OF DURABILITY BY HAND.	

INITIAL UNMATING

SAMPLE #1 MB74 - ONE BRISTLE OUT TOWARD CAVITY WALL

A35 - TWO TINES DISPLAYED SKIVING, ROLLING MOLDING MATERIAL DOWN INTO CAVITY.

B45 - HAD ONLY 5 BRISTLES INSTEAD OF PLANNED SIX. PREPARED 5/6 BRISTLE CONTACTS LOOKED GOOD.

#1 DB - O.K.

SAMPLE #2 MB - CAVITIES A26, A29, A45, B27, B37, B41 AND B45 DISPLAYED MINOR SKIVING OF MOLDING AT BASE OF RETENTION TINES. NO CHANGE APPARENT OF THE PREPARED BENT WIRES. (BRISTLES)

#2 DB - O.K. - NO CHANGE APPARENT OF THE PREPARED BENT BRISTLES.

AFTER 1000 CYCLES OF DURABILITY.

SAMPLE #1 MB - A35 SKIVING OF TWO TINES.
- A1 " (MINOR).
- B74 " (MINOR).
PREPARED 5/6 BRISTLE CONTACTS, NO DAMAGE, LOOK GOOD.

DB - O.K., NO DAMAGE, NO APPARENT CHANGE.

SAMPLE #2 MB - CAVITIES DISPLAYED SKIVING IN VARYING DEGREES:
A26, A28, A29, A35, A44, A45, B27, B35, B37, B41, B45 & B12.
A46 WIRE BRISTLE BENT OVER.
A44 ONE BRISTLE BENT OVER.
A26 " " " " .
A43 TWO " (X) " " .
A45 ONE " " " .

DB - O.K., NO DAMAGE, NO APPARENT CHANGE EVEN OF PREPARED BENT WIRES.

REF: EWDM 6997. ECL0592-35&-36.	Bendix Electrical Components Division, Sidney, New York 13838	TESTED BY: TR. BAIRD R.D. WAGHORN
		APPROVED BY:
		WITNESSED BY:

LABORATORY DATA SHEET

TEST	DATE OF TESTS	REPORT NUMBER
CONTACT RESISTANCE - INITIAL (MATING)	10-19-78	2375

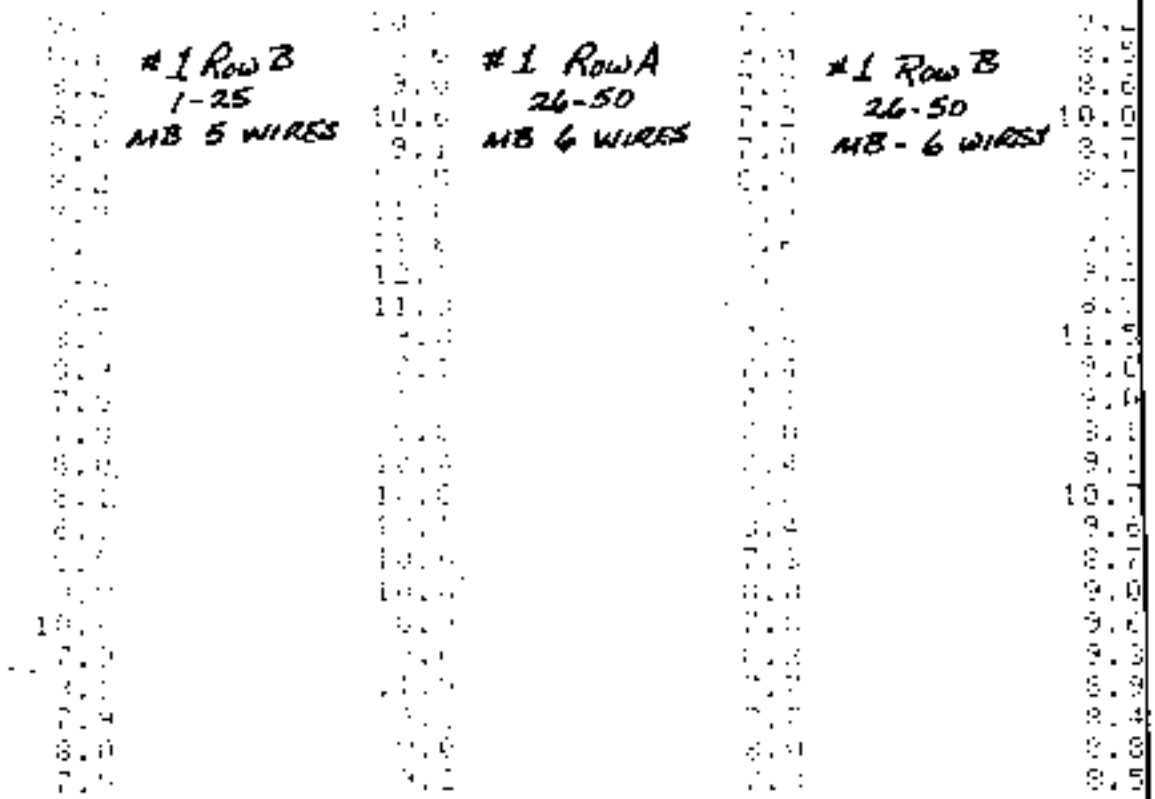
TEST SPECIMEN IS!	TEMP.	R.H.	ECL
10-602542-1 50MC, 10-602542-150 DC	73°F	45%	0592A-35

LT.	SPEC.	PARA.
4924		

TEST EQUIPMENT	CAL DATE	DUE DATE
KEITHLEY 503 MILLIOHMMETER E-1162	2-22-78	3-8-79
H-P 3480A DIGITAL VOLTMETER E0392	9-6-78	3-6-79
HP 3489A DATA PUNCH E-2102	N/A	N/A

SPEC LIMITS

TEST CONDITIONS
ROOM AMBIENT.
30 MILLIOHMS FULL SCALE
K = 2.292



NO. OF SAMPLES=	NO. OF SAMPLES=	NO. OF SAMPLES=	NO. OF SAMPLES=
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MEAN=	MEAN=	MEAN=	MEAN=
9.3		10.1	9.1
MINIMUM=	MINIMUM=	MINIMUM=	MINIMUM=
8.1		7.1	8.1
STD. DEV.=	STD. DEV.=	STD. DEV.=	STD. DEV.=
.5		.8	.5
U.C.L.=	U.C.L.=	U.C.L.=	U.C.L.=
			11.5

REF EWDM 0997
ECL0592-35.

Bendix Electrical Components Division
Sidney, New York 13838

TESTED BY R.D. WAGHORN
T.R. BAIRD
APPROVED BY
WITNESSED BY

LABORATORY DATA SHEET

TEST: Contact Resistance - Initial (1st Mating)		DATE OF TESTS: 10-20-78	REPORT NUMBER: 2375
TEST SPECIMEN (S): 10-502542-150 MB, 10-502562-150 DB		TEMP: 73°F RH: 42%	ECL: 0592A-36
	EI: 4924	SPEC	PARA
TEST EQUIPMENT: Keithly 503 Millionmmeter F-1662	CAL DATE: 2-22-78	DUE DATE: 3-8-79	SPEC. LIMITS
H-P 3480A Digital Voltmeter F-0392	9-6-78	3-6-79	TEST CONDITIONS: Room Ambient. 30 Millionhm Full Scale K= 2.292
H-P 3489A Data Punch F-2103	N/A	N/A	

#2 Row A 1-25 DB 1 Bent Wire	#2 Row B 1-25 DB 1 Bent Wire	#2 Row A 26-50 MB 1 Bent Wire	#2 Row B 26-50 MB 1 Bent Wire
NO. OF SAMPLES=	NO. OF SAMPLES=	NO. OF SAMPLES=	NO. OF SAMPLES= 25
MAXIMUM= 10.4	MAXIMUM= 10.6	MAXIMUM= 8.7	MAXIMUM= 10.7
MEAN= 9.2	MEAN= 9.4	MEAN= 7.8	MEAN= 9.4
MINIMUM=	MINIMUM=	MINIMUM=	MINIMUM= 8.1
STD. DEV.=	STD. DEV.=	STD. DEV.=	STD. DEV.= .7
U.C.L.= 10.4	U.C.L.=	U.C.L.=	U.C.L.= 10.3

REF. EWDM 6997, ECL 0592-35.

Bendix Electrical Components Division
Sidney, New York 13838

TESTED BY: R.D. WAGHORN

APPROVED BY:

WITNESSED BY:

LABORATORY DATA SHEET

TEST: Contact Resistance - Initial (1st mating)			DATE OF TESTS: 10-19-78 / 10-20-78	REPORT NUMBER: 2375
TEST SPECIMEN(S): 10-502592-150 MB, 10-502562-150 DB			TEMP: 75°F / R.H.: 49%	ECL: 0592A-37
		JT: 4924	SPEC	PARA
TEST EQUIPMENT: Keithley 503 Milliohmmeter F-1662	CAL DATE: 2-22-78	DUE DATE: 3-8-79	SPEC. LIMITS	
H-P 3480A Digital Voltmeter F-0392	9-6-78	3-6-79	TEST CONDITIONS: Room Ambient. 30 Milliohms Full Scale. K= 2.292	
H-P 3489A Data Punch F-2103	N/A	N/A		

10-19-78 #1 Row A 51-75 7 wires	10-19-78 #1 Row B 51-75 7 wires	10-20-78 #2 Row A 51-75 7 wires	10-20-78 #2 Row B 51-75 7 wires
[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	8.6

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MEAN= [illegible]	MEAN= [illegible]	MEAN= [illegible]	MEAN= 8.6
MINIMUM= [illegible]	MINIMUM= [illegible]	MINIMUM= [illegible]	MINIMUM= 7.8
STD. DEV.= [illegible]	STD. DEV.= [illegible]	STD. DEV.= [illegible]	STD. DEV.= [illegible]
[illegible]	[illegible]	[illegible]	[illegible]

REF: EWOM G997, ECL0592-35.	Bendix Electrical Components Division, Sidney, New York 13838	TESTED BY: R. D. Waghorn, T.R. Baird
		APPROVED BY
		WITNESSED BY

72-354-2

LABORATORY DATA SHEET

TEST: CONTACT RESISTANCE AFTER 200 CYCLES OF DURABILITY		DATE OF TESTS: 11/1/78	REPORT NUMBER: 2375
TEST SPECIMEN (S): 10-502342-100 MK, 10-502562-150 ZS		TEMP: 75°F; R.H.: 22%	ECL 0592A-38 EPL
	LT 492-1	SPEC.	PARA.
TEST EQUIPMENT: KEITHLY 203 MILLIOHMMETER F-1142	CAL DATE: 2-22-78	DUE DATE: 3-8-79	SPEC LIMITS
H-P 3480A DIGITAL VOLTMETER F-0392	9-6-78	3-6-79	TEST CONDITIONS: ROOM AMBIENT; 30 MILLIOHMS FULL SCALE
H-P 3489A DATA RUNCH F-2103	N/A	N/C	
			K = 2.292

#1 Row A
1-25
MB 5 WIRES

#1 Row B
1-25
MB 5 WIRES

#1 Row A
26-50
MB 6 WIRES

#1 Row B
26-50
MB 6 WIRES

NO. OF SAMPLES=	NO. OF SAMPLES=	NO. OF SAMPLES=	NO. OF SAMPLES=
MAXIMUM= 25	MAXIMUM= 25	MAXIMUM= 25	MAXIMUM= 25
MEAN=	MEAN=	MEAN=	MEAN=
MINIMUM=	MINIMUM=	MINIMUM=	MINIMUM=
STD. DEV.=	STD. DEV.=	STD. DEV.=	STD. DEV.=
U.T.L.=	U.T.L.=	U.T.L.=	U.T.L.=

REF EWDM 6997.
ECL0592-35.

Bendix Electrical Components Division
Sidney, New York 13838

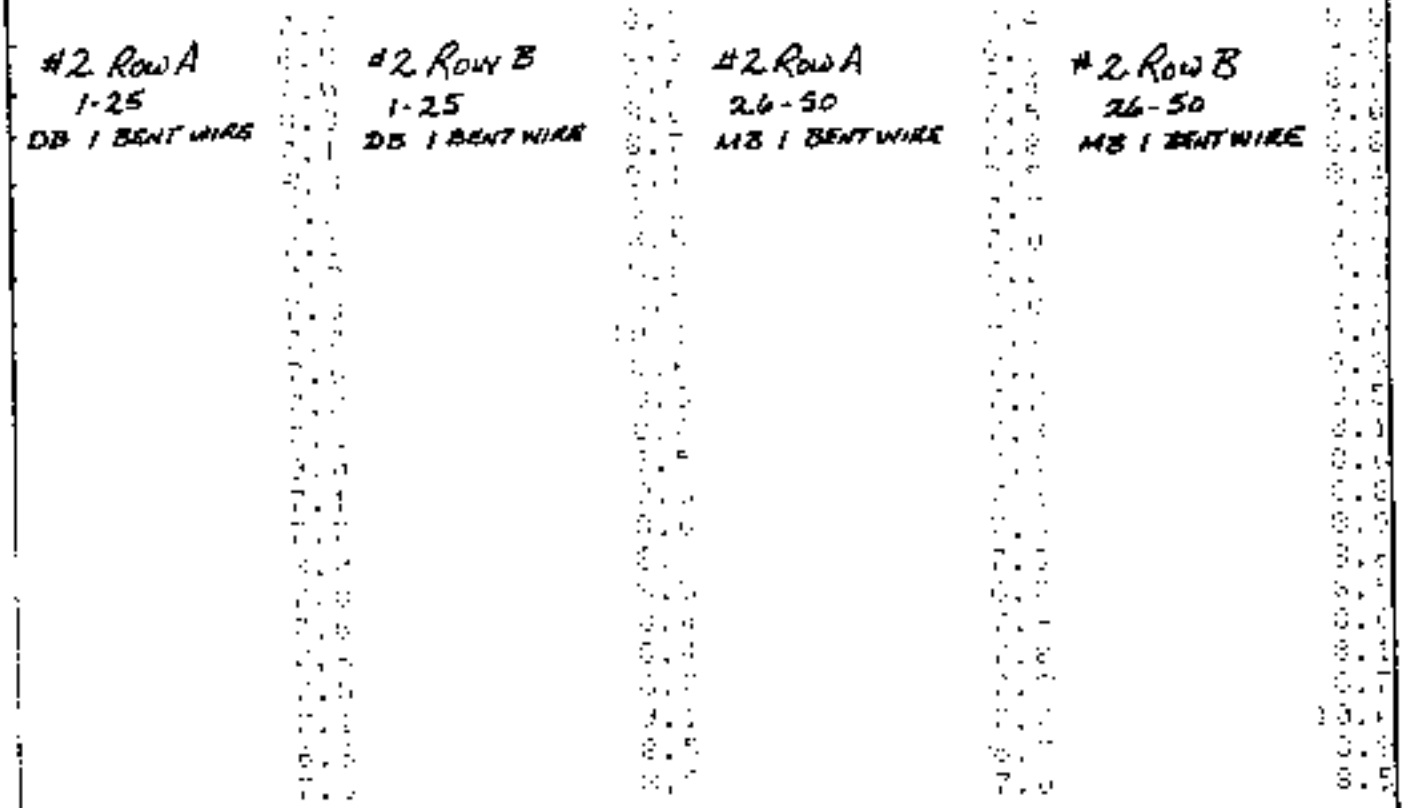
TESTED BY T.R. BAIRD
R.D. WAGHORN

APPROVED BY

WITNESSED BY

LABORATORY DATA SHEET

TEST: CONTACT RESISTANCE - AFTER 250 CYCLES OF DURABILITY		DATE OF TESTS: 11-1-78	REPORT NUMBER: 2375
TEST SPECIMEN(S): M-502542-150 MG, 10-502562-150 DB		TEMP: 75°F; H.H.: 32%	ECL0592A-39
	LT 4324	SPEC.	PARA
TEST EQUIPMENT: KEITHLEY MODEL 503 MILLIOHMMETER E-1662	CAL DATE: 2-22-78	DUE DATE: 3-8-79	SPEC LIMITS
H-P 3480A DIGITAL VOLTMETER E-0322	9-6-78	3-6-79	TEST CONDITIONS: ROOM AMBIENT
H-P 3489A DATA HUNCH E-2103	N/A	N/A	30 MILLIOHMS FULL SCALE
			K=2.292



NO. OF SAMPLES= 25	NO. OF SAMPLES= 25	NO. OF SAMPLES= 25	NO. OF SAMPLES= 25
MAXIMUM= 9.4	MAXIMUM= 10.1	MAXIMUM= 7.5	MAXIMUM= 10.8
MEAN= 7.4	MEAN= 9.0	MEAN= 7.2	MEAN= 8.6
MINIMUM= 6.5	MINIMUM= 7.7	MINIMUM= 6.7	MINIMUM= 8.1
STD. DEV.=	STD. DEV.=	STD. DEV.=	STD. DEV.=
U.C.L.=	U.C.L.=	U.C.L.=	U.C.L.=

REF: EWOM G997.
ECL0592-35.

Bendix Electrical Components Division
Sidney, New York 13838

TESTED BY: MR. BRAID
R. D. WAGHORN

APPROVED BY:

WITNESSED BY:

LABORATORY DATA SHEET

TEST: CONTACT RESISTANCE - AFTER 250 CYCLES OF DURABILITY		DATE OF TESTS: 11-1-78	REPORT NUMBER: 2395
TEST SPECIMEN(S): 10-502592-150 MS; 10-502592-150 DK		TEMP: 75°F; R.H.: 32%	ECL-0592A-40
	US 4924	SPEC.	PSRA
TEST EQUIPMENT: KELVIN MODEL 583 MILLIOHMMETER F-1562	CAL DATE: 2-22-78	DUE DATE: 8-9-79	SPEC LIMITS
H-P 3480 A DIGITAL VOLTMETER F-0392	9-6-78	2-6-79	TEST CONDITIONS: ROOM AMBIENT
H-P 3489 A DATA HAUCH F-2105	N/A	N/A	30 MILLIONMS FULL SCALE
			K=2.292

#1 ROW A 51-75 7 WIRES	#1 ROW B 51-75 7 WIRES	#2 ROW A 51-75 7 WIRES	#2 ROW B 51-75 7 WIRES
NO. OF SAMPLES=	NO. OF SAMPLES=	NO. OF SAMPLES=	NO. OF SAMPLES=
MAXIMUM=	MAXIMUM=	MAXIMUM=	MAXIMUM=
MEAN=	MEAN=	MEAN=	MEAN=
MINIMUM=	MINIMUM=	MINIMUM=	MINIMUM=
STD. DEV.=	STD. DEV.=	STD. DEV.=	STD. DEV.=
U.C.L.=	U.C.L.=	U.C.L.=	U.C.L.=

REF: EWOM G997. ECL0592-35.

Bendix Electrical Components Division
Sidney, New York 13838

TESTED BY: T.R. BAIRD, R.D. WAGNER
APPROVED BY:
WITNESSED BY:

LABORATORY DATA SHEET

TEST: Contact Resistance - After 500 cycles of durability		DATE OF TESTS: 11-2-78	REPORT NUMBER: 2375
TEST SPECIMEN(S): 10-502572-150 MB, 10-502562-150 DB		TEMP: 79°F · RH: 28%	ECL0592A-42
	-7324	SPEC	PARA
TEST EQUIPMENT: Keithly Model 503 Milliohmmeter 2-662	CAL DATE: 2-22-78 · DUE DATE: 3-8-79	SPEC LIMITS	
H-P 3480A Digital Voltmeter E-0392	9-6-78 · 3-6-79	TEST CONDITIONS: Room Ambient	
H-P 3489A Data Hinch E-2103	N/A · N/A	30 Milliohms Full Scale	
		K=1.292	

#1 Row A 1-25 MB 5 wires	#1 Row B 1-25 MB 5 wires	#1 Row A 26-50 MB 6 wires	#1 Row B 26-50 MB 6 wires
[illegible]	[illegible]	[illegible]	[illegible]
	10.[illegible]		8.4
			8.1

NO. OF SAMPLES= 25	NO. OF SAMPLES= 25	NO. OF SAMPLES= 25	NO. OF SAMPLES= 25
MAXIMUM= [illegible]	MAXIMUM= 11.[illegible]	MAXIMUM= 8.[illegible]	MAXIMUM= 10.3
MEAN= [illegible]	MEAN= [illegible]	MEAN= 7.[illegible]	MEAN= 8.7
MINIMUM= [illegible]	MINIMUM= [illegible]	MINIMUM= [illegible]	MINIMUM= [illegible]
STD. DEV.= [illegible]	STD. DEV.= [illegible]	STD. DEV.= [illegible]	STD. DEV.= [illegible]
U.C.L.= [illegible]	U.C.L.= [illegible]	U.C.L.= [illegible]	U.C.L.= [illegible]

REF: EWOM G997. ECL0592-36.

Bendix Electrical Components Division

TESTED BY: T.R. Baird, R.D. Waghorn

APPROVED BY

WITNESSED BY

72-354-2

LABORATORY DATA SHEET

TEST: Contact Resistance - After 500 cycles of durability		DATE OF TESTS: 11-2-78	REPORT NUMBER: 2375
TEST SPECIMEN (S): 10-502542-150 MS, 10-502562-150 DB		TEMP: 74°F RH: 28%	ECL: 3924-43
	LT: 4529	SPEC.	PARA
TEST EQUIPMENT: Keithley Model 503 Millionmmeter E-1662	CAL DATE: 2-22-78	DUE DATE: 3-9-79	SPEC LIMITS
H-P 3-180 A Digital Voltmeter E-5392	9-6-78	3-6-79	TEST CONDITIONS: Room Ambient
H-P 3489 A Data Punch E-2103	N/A	N/A	30 Millionms Full Scale
			K=2.292

#2 Row A
1-25
DB 1 BENT WIRE

#2 Row B
1-25
DB 1 BENT WIRE

#2 Row A
26-50
MB 1 BENT WIRE

#2 Row B
26-50
MB 1 BENT WIRE

NO. OF SAMPLES=	NO. OF SAMPLES=	NO. OF SAMPLES=	NO. OF SAMPLES=
MEAN=	MEAN=	MEAN=	MEAN=
STD. DEV.=	STD. DEV.=	STD. DEV.=	STD. DEV.=

REF: EWOM G997.
ECL0592-36.

Bendix Electrical Components Division
Sidney, New York 13838

TESTED BY: R.R. BAIRD
R.D. WAGNORN

APPROVED BY:

WITNESSED BY:

LABORATORY DATA SHEET

TEST: Contact Resistance - After 500 cycles of durability		DATE OF TESTS: 11.2.78	REPORT NUMBER: 2375
TEST SPECIMEN (S): 10-502542-153 MB, 10-502542-150 DB		TEMP: 74°F RH: 28%	LCL05928-44 SPL
	LT 4524	SPEC.	PARA
TEST EQUIPMENT: Keithley Model 503 Milliohmmeter	E-1462	CAL DATE: 2.22.78	DUE DATE: 3-8-79
H-P 3480A Digital Voltmeter	E-0392	9-6-78	3-6-79
H-P 3488A Data Munch	E-2103	N/A	N/A

SPEC LIMITS

TEST CONDITIONS
Room Ambient
30 Millionths Full Scale

K=2.292

#1 Row A
51-75
7 WIRES

#1 Row B
51-75
7 WIRES

#2 Row A
51-75
7 WIRES

#2 Row B
51-75
7 WIRES

NO. OF SAMPLES=	NO. OF SAMPLES=	NO. OF SAMPLES=	NO. OF SAMPLES=
MAXIMUM=	MAXIMUM=	MAXIMUM=	MAXIMUM=
MEAN=	MEAN=	MEAN=	MEAN= 10.1
MINIMUM=	MINIMUM=	MINIMUM=	MINIMUM=
STD. DEV.=	STD. DEV.=	STD. DEV.=	STD. DEV.=
U.C.L.=	U.C.L.=	U.C.L.=	U.C.L.=

REF: EWOM 6997.
ECL0592-36.

Bendix Electrical Components Division
Sidney, New York 13838

TESTED BY: T.R. BAIRD
R.D. WAGHORN

APPROVED BY:

WITNESSED BY:

LABORATORY DATA SHEET

TEST: CONTACT RESISTANCE - AFTER 150 CYCLES OF DURABILITY			DATE OF TESTS: 11.2.78		REPORT NUMBER: 2375
TEST SPECIMEN (S): M-502542-150 MS; 10-502562-150 DE			TEMP: 82°F	RH: 25%	ECL: 0592A-45
		LF: 4924	SPEC:		PARA:
TEST EQUIPMENT: KEITHLY MODEL 503 MILLIOHMMETER F-1162	CAL DATE: 2.22.78	DUE DATE: 3.8.79	SPEC LIMITS:		
H-P 3480A DIGITAL VOLTMETER F-0392	9.6.78	3.6.79	TEST CONDITIONS: ROOM AMBIENT		
H-P 3489A DATA HUNCH F-2103	N/A	N/A	30 MILLIOHMS FULL SCALE		
			K=2.292		

#1 ROW A 1-25 MB 5 WIRES	#1 ROW B 1-25 MB 5 WIRES	#1 ROW A 26-50 MB 6 WIRES	#1 ROW B 26-50 MB 6 WIRES
NO. OF SAMPLES= 25	NO. OF SAMPLES= 25	NO. OF SAMPLES= 25	NO. OF SAMPLES= 25
MAXIMUM= 10.1	MAXIMUM= 10.2	MAXIMUM= 9.2	MAXIMUM= 10.2
MEAN= 7.4	MEAN= 8.1	MEAN= 7.4	MEAN= 8.1
MINIMUM= 5.5	MINIMUM= 6.4	MINIMUM= 5.5	MINIMUM= 7.0
STD. DEV.= .9	STD. DEV.= .7	STD. DEV.= .7	STD. DEV.= .5
U.C.L.= 9.6	U.C.L.= 9.9	U.C.L.= 8.9	U.C.L.= 9.5

REF: EWOM G997. ECL0592-36.

Bendix Electrical Components Division, Sidney, New York 13838

TESTED BY: T.R. BAIRD, R.D. WAGHORN

APPROVED BY:

WITNESSED BY:

LABORATORY DATA SHEET

TEST: CONTACT RESISTANCE - AFTER 750 CYCLES OF DURABILITY		DATE OF TESTS: 11-2-78	REPORT NUMBER: 2375
TEST SPECIMEN (S): 10-602592-150 MB; 10-602592-150 DB		TEMP: 82°F; R.H.: 25%	ECL: ECL0592A-46
	LT: 4929	SPEC	PARA.
TEST EQUIPMENT: KEITHLY MODEL 503 MILLIOHMMETER E-1562	CAL DATE: 12-22-78	OUE DATE: 3-8-79	SPEC. LIMITS
H-P 3480A DIGITAL VOLTMETER E-0302	3-6-79	3-6-79	TEST CONDITIONS: ROOM AMBIENT; 30 MILLIOHMS FULL SCALE
H-P 3489A DATA PUNCH E-2103	N/A	N/A	
			K=2.292

#2 ROW A
1-25
DB 1 BENT WIRE

#2 ROW B
1-25
DB 1 BENT WIRE

#2 ROW A
26-50
MB 1 BENT WIRE

#2 ROW B
26-50
MB 1 BENT WIRE

NO. OF SAMPLES= 25	NO. OF SAMPLES= 25	NO. OF SAMPLES= 25	NO. OF SAMPLES= 25
MAXIMUM= 9.1	MAXIMUM= 9.7	MAXIMUM= 7.7	MAXIMUM= 9.7
MEAN= 7.1	MEAN= 8.1	MEAN= 7.2	MEAN= 8.8
MINIMUM= 5.4	MINIMUM= 6.5	MINIMUM= 6.3	MINIMUM= 7.6
STD. DEV.= .8	STD. DEV.= .8	STD. DEV.= .4	STD. DEV.= .4
U.C.L.= 9.1	U.C.L.= 9.7	U.C.L.= 7.9	U.C.L.= 9.1

REF: EWDM G997.
ECL0592-36.

Bendix Electrical Components Division
Sidney, New York 13838

TESTED BY: R. BAIRD
R. D. WAGNORU

APPROVED BY:

WITNESSED BY:

LABORATORY DATA SHEET

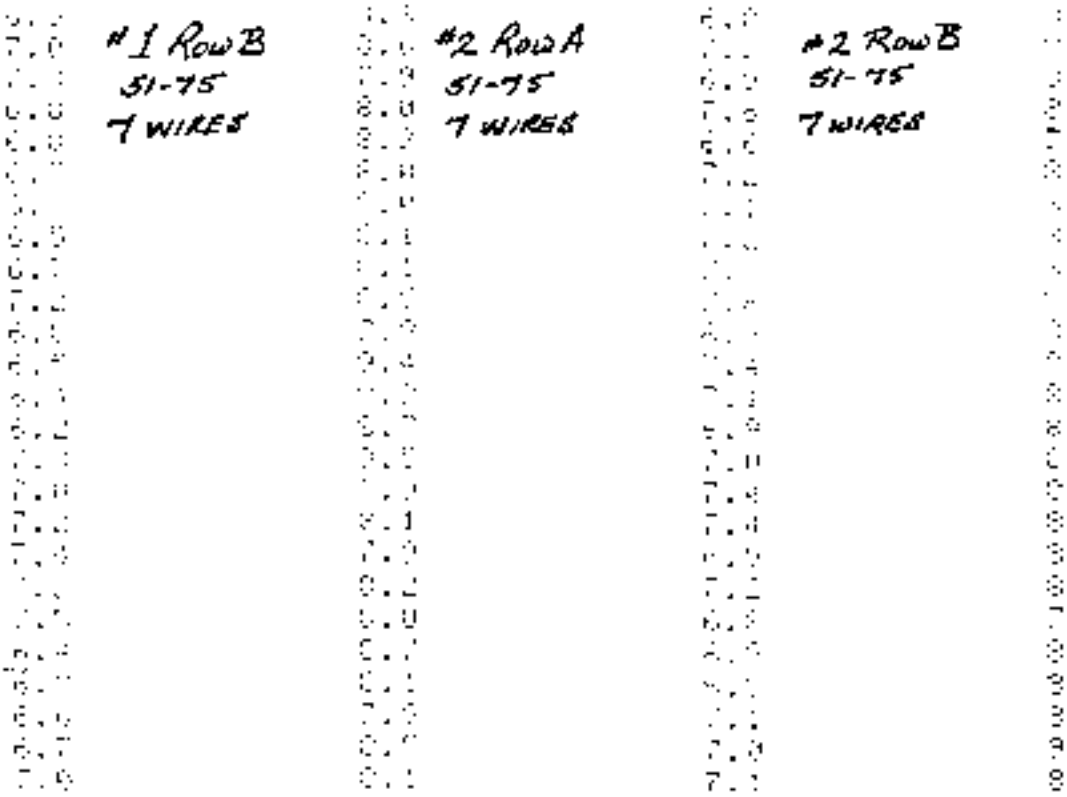
TEST: Contact Resistance - After 750 Cycles of Durability			DATE OF TESTS: 11-2-78	REPORT NUMBER: 2395
TEST SPECIMEN ID: 10-602542-150 MB; 10-602532-150 DB			TEMP: 82°F; R.H.: 25%	ECN: 105924-47
		LI: 4924	SPEC	PARA
TEST EQUIPMENT: Keithley Model 503 Milliohmmeter E-1562	CAL DATE: 2-22-78	DUE DATE: 3-8-79	SPEC LIMITS	
H-P 3480A Digital Voltmeter E-0592	9-6-78	3-6-79	TEST CONDITIONS: Room Ambient	
H-P 3488A Data Hunch E-2103	N/A	N/A	30 Milliohms Full Scale	
			K=2.292	

#1 Row A
51-75
7 WIRES

#1 Row B
51-75
7 WIRES

#2 Row A
51-75
7 WIRES

#2 Row B
51-75
7 WIRES



NO. OF SAMPLES=	NO. OF SAMPLES=	NO. OF SAMPLES=	NO. OF SAMPLES=
MAXIMUM= 25	MAXIMUM= 25	MAXIMUM= 25	MAXIMUM= 25
MEAN= 7.5	MEAN= 9.9	MEAN= 9.9	MEAN= 7.7
MINIMUM= 6.9	MINIMUM= 8.4	MINIMUM= 8.3	MINIMUM= 7.1
STD. DEV.= 0.2	STD. DEV.= 0.3	STD. DEV.= 0.3	STD. DEV.= 0.2
K.C.L.=	K.C.L.=	K.C.L.=	K.C.L.=

REF: EWDM G997.
ECL0592-36.

Bendix Electrical Components Division
Sidney, New York 13838

TESTED BY: T.R. BAIRD
R.D. WAGHORN

APPROVED BY:

WITNESSED BY:

LABORATORY DATA SHEET

TEST: Contact Resistance - After 1000 cycles of durability		DATE OF TESTS: 11-3-78	REPORT NUMBER: 2375
TEST SPECIMEN (S): M-502542-150 MB, 10-502562-150 DB		TEMP: 74°F / R.H. 36%	ECL: 0592A-48 APL:
	LT 4924	SPEC	PARA
TEST EQUIPMENT: Keithly Model 503 Milliohmmeter F-1662	CAL DATE: 2-22-78	DUE DATE: 3-8-79	SPEC LIMITS
H-P 3480A Digital Voltmeter F-0392	9-6-78	3-6-79	TEST CONDITIONS: Room Ambient
H-P 3489A Data Punch F-2103	N/A	N/A	30 Millionms Full Scale
			K=2.292

#1 Row A 1-25 MB 5 WIRES	#1 Row B 1-25 MB 5 WIRES	#1 Row A 26-50 MB 6 WIRES	#1 Row B 26-50 MB 6 WIRES
NO. OF SAMPLES=	NO. OF SAMPLES=	NO. OF SAMPLES=	NO. OF SAMPLES=
MAXIMUM=	MAXIMUM=	MAXIMUM=	MAXIMUM=
MEAN=	MEAN=	MEAN=	MEAN=
MINIMUM=	MINIMUM=	MINIMUM=	MINIMUM=
STD. DEV.=	STD. DEV.=	STD. DEV.=	STD. DEV.=
TOTAL=	TOTAL=	TOTAL=	TOTAL=

REF: EWDM 6997. ECL0592-36.

Bendix Electrical Components Division

Sidney, New York 13838

TESTED BY: T.R. BAIRD, R.D. WAGHORN

APPROVED BY:

WITNESSED BY:

LABORATORY DATA SHEET

TEST	DATE OF TESTS	REPORT NUMBER
Contact Resistance - After 1000 cycles of durability	11-3-78	2375

TEST SPECIMEN(S)	TEMP	% RH	
10-502592-150 MB, 10-502592-150 DB	74°F	36%	EC10592A-49

	LT	SPEC	PARA
	4324		

TEST EQUIPMENT		CAL DATE	DUE DATE
Keithley Model 503 Milliohmmeter	E-662	2-22-78	3-8-79
H-P 3480 A Digital Voltmeter	E-0392	9-6-78	3-6-79
H-P 3489 A Data Punch	E-2103	N/A	N/A

SPEC LIMITS

TEST CONDITIONS
Room Ambient
30 Milliohms Full Scale

K=2.292

#2 Row A 1-25 DB / Bent wire	#2 Row B 1-25 DB / Bent wire	#2 Row A 26-50 MB / Bent wire	#2 Row B 26-50 MB / Bent wire
[illegible]	[illegible]	[illegible]	[illegible]

NO. OF SAMPLES= 25	NO. OF SAMPLES= 25	NO. OF SAMPLES= 25	NO. OF SAMPLES= 25
MAXIMUM= [illegible]	MAXIMUM= [illegible]	MAXIMUM= 8.0	MAXIMUM= 9.7
MEAN= [illegible]	MEAN= 8.4	MEAN= [illegible]	MEAN= 8.7
MINIMUM= [illegible]	MINIMUM= [illegible]	MINIMUM= [illegible]	MINIMUM= 7.9
STD. DEV.= [illegible]	STD. DEV.= [illegible]	STD. DEV.= [illegible]	STD. DEV.= [illegible]
[illegible]	[illegible]	[illegible]	[illegible]

REF EWOM G997.
EC10592-36.

Bendix Electrical Components Division
Sidney, New York 13838

TESTED BY T.R. BAIRD
R.D. WAGNER

APPROVED BY

WITNESSED BY

LABORATORY DATA SHEET

TEST: Contact Resistance – After 1000 cycles of durability			DATE OF TESTS: 11-3-78	REPORT NUMBER: 2375
TEST SPECIMEN(S): 10-502592-150 MS, 10-502562-150 DS			TEMP: 74°F · RH: 36%	ECL0592A-50
		W.O. 4324	SPEC	PARA
TEST EQUIPMENT: Keithly Model 503 Milliohmmeter E-1662	CAL DATE: 2-22-78	DUE DATE: 3-8-79	SPEC LIMITS	
H-P 3480A Digital Voltmeter E-0392	9-6-78	3-6-79	TEST CONDITIONS: Room Ambient; 30 Milliohms Full Scale; K=2.292	
H-P 3489A Data Punch E-2193	N/A	N/A		

#1 Row A
51-75
7 WIRES

#1 Row B
51-75
7 WIRES

#2 Row A
51-75
7 WIRES

#2 Row B
51-75
7 WIRES

#1 Row A	#1 Row B	#2 Row A	#2 Row B
[illegible]	[illegible]	[illegible]	[illegible]

#1 Row A	#1 Row B	#2 Row A	#2 Row B
NO. OF SAMPLES= [illegible]	NO. OF SAMPLES= [illegible]	NO. OF SAMPLES= [illegible]	NO. OF SAMPLES= 25
MAXIMUM= [illegible]	MAXIMUM= [illegible]	MAXIMUM= 7.4	MAXIMUM= 9.7
MEAN= [illegible]	MEAN= [illegible]	MEAN= [illegible]	MEAN= 8.4
MINIMUM= [illegible]	MINIMUM= [illegible]	MINIMUM= [illegible]	MINIMUM= 7.8
STD. DEV.= [illegible]	STD. DEV.= [illegible]	STD. DEV.= [illegible]	STD. DEV.= .4
[illegible]	[illegible]	[illegible]	[illegible]

REF: EWAM G997. ECL0592-36.

Bendix Electrical Components Division
Sidney, New York 13838

TESTED BY: T.R. Baird, R.D. Wachoru

APPROVED BY:

WITNESSED BY:

72-354-2

APPENDIX B
Photographs

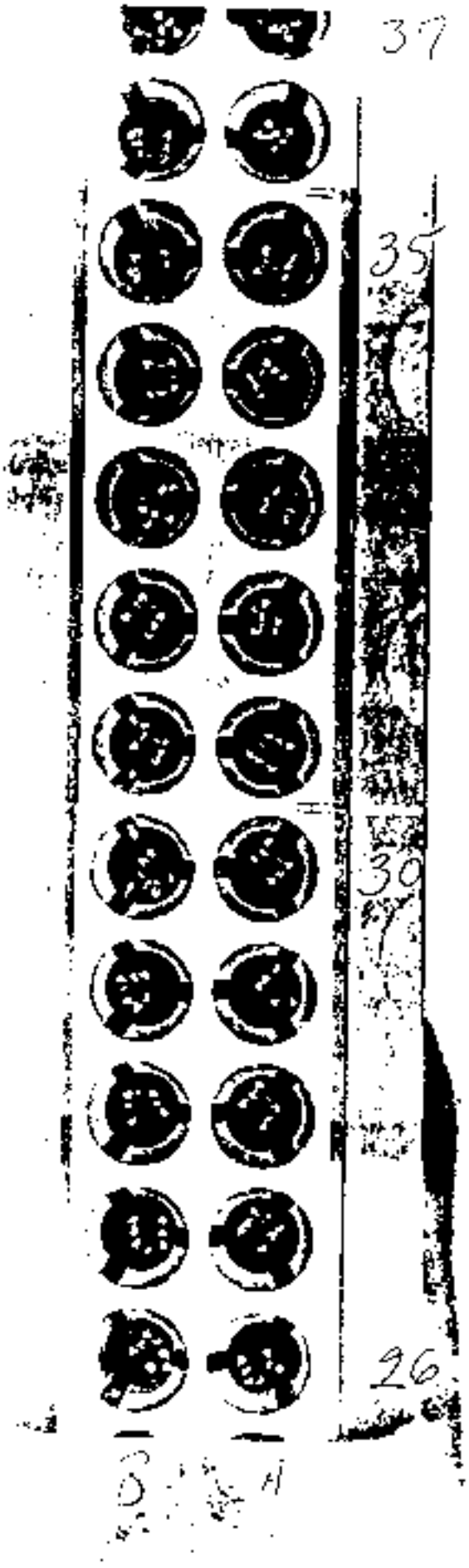


FIGURE 1

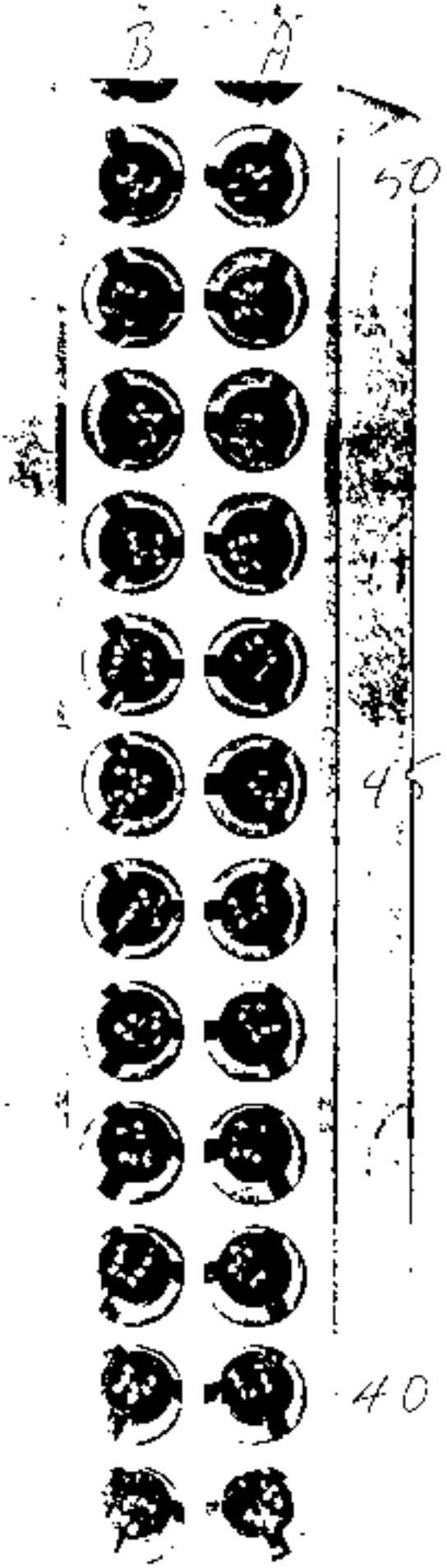


FIGURE 2

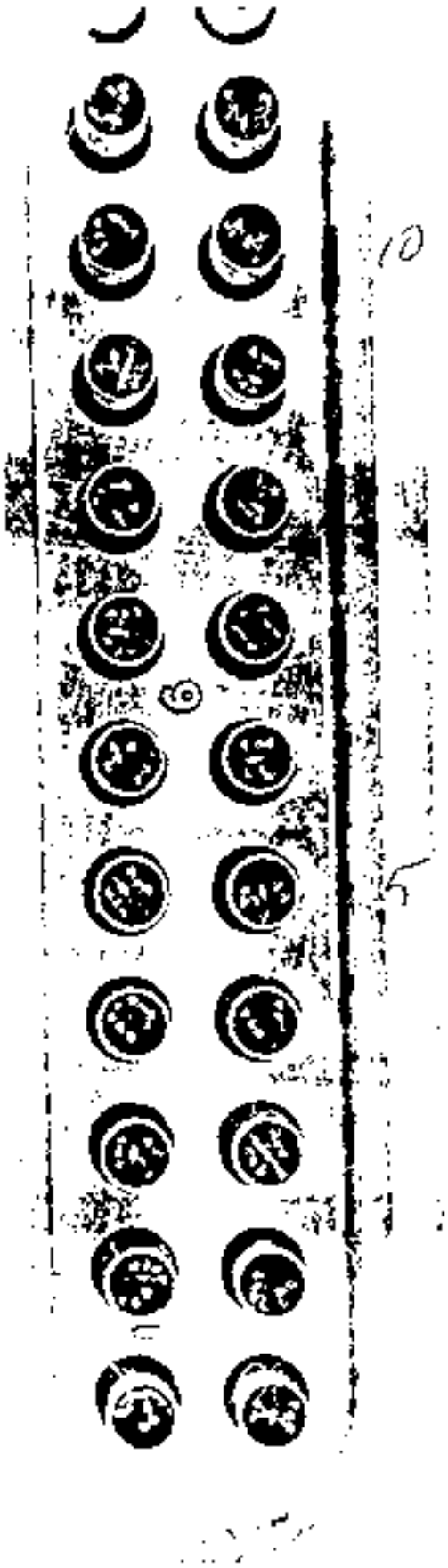


FIGURE 3

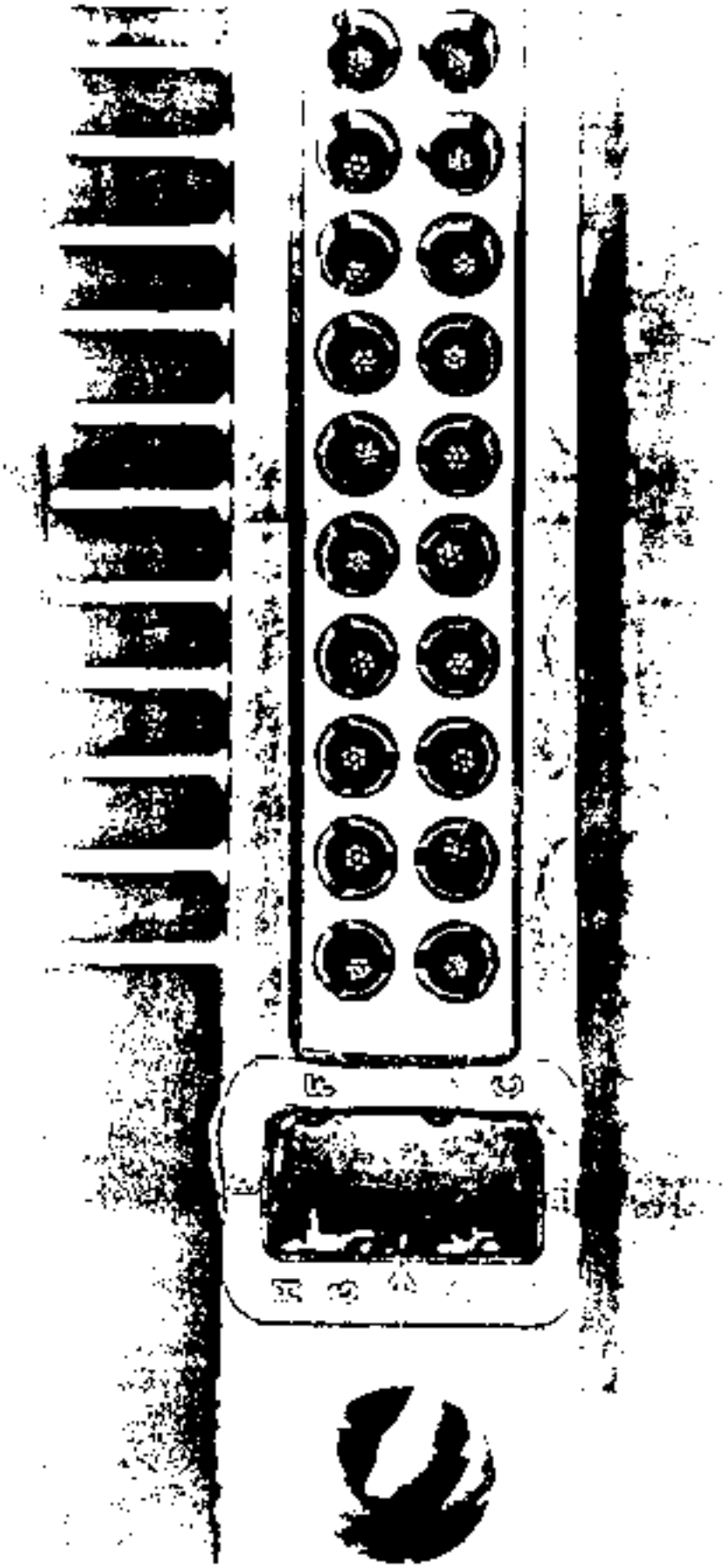


FIGURE 5

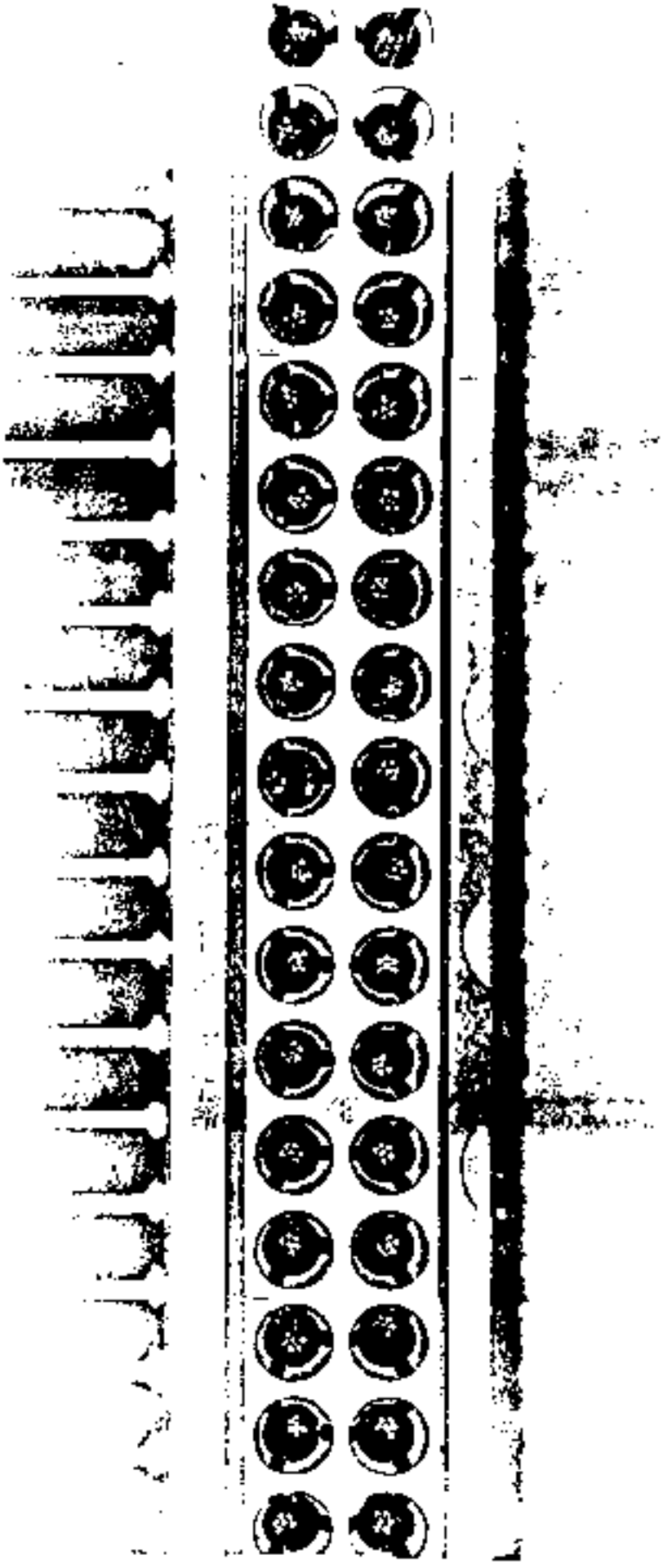


FIGURE 6

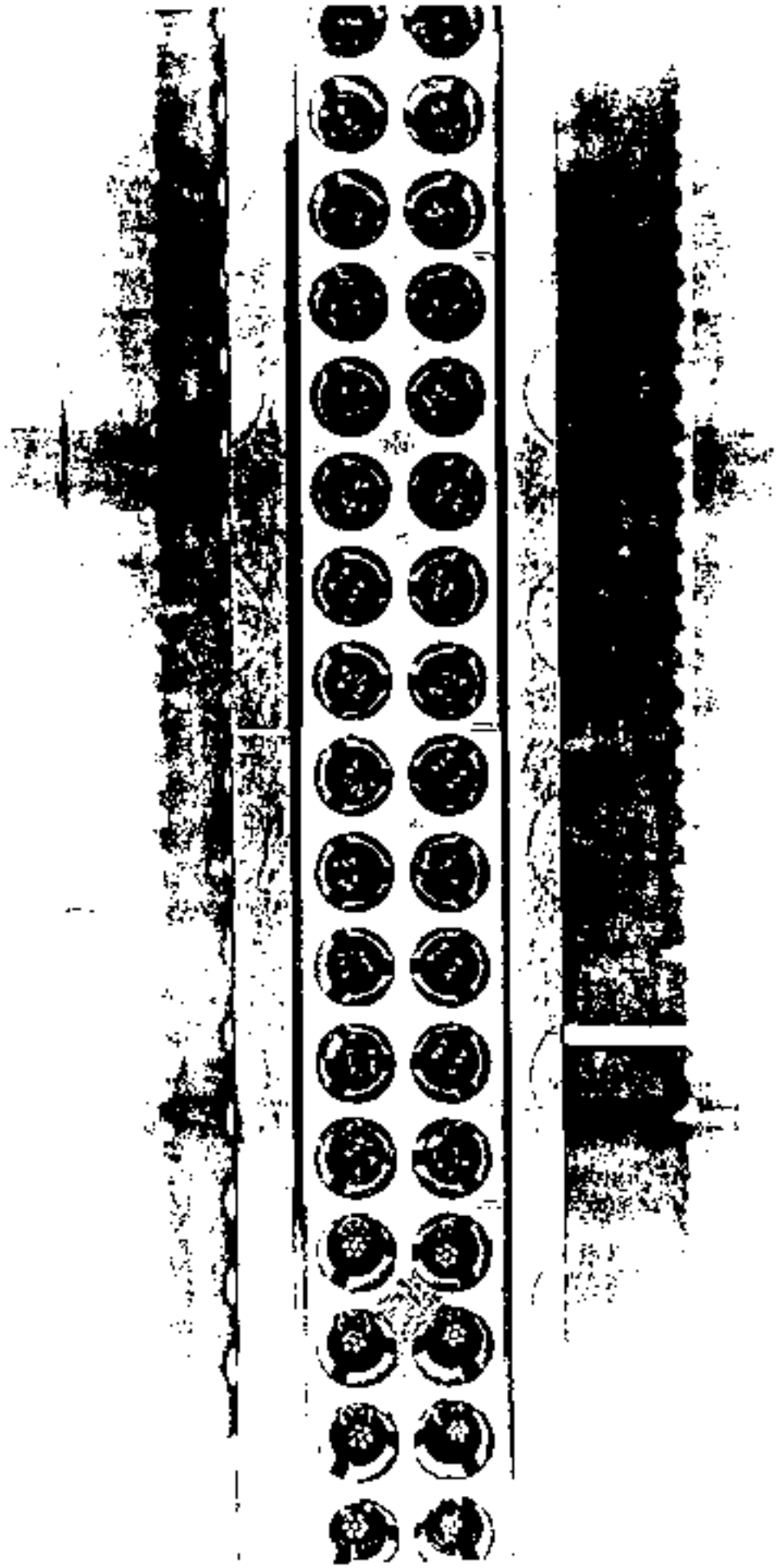


FIGURE 7

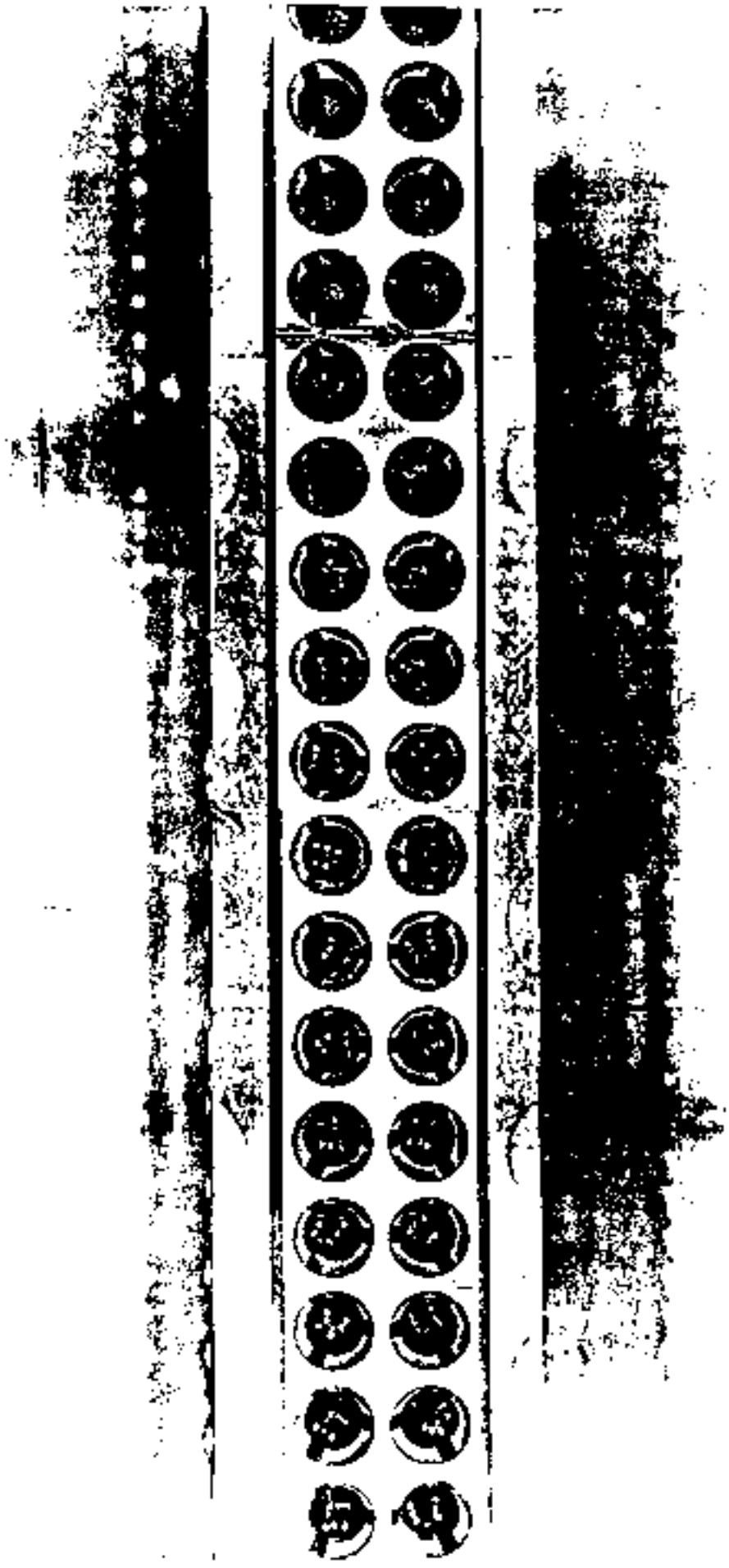


FIGURE 8

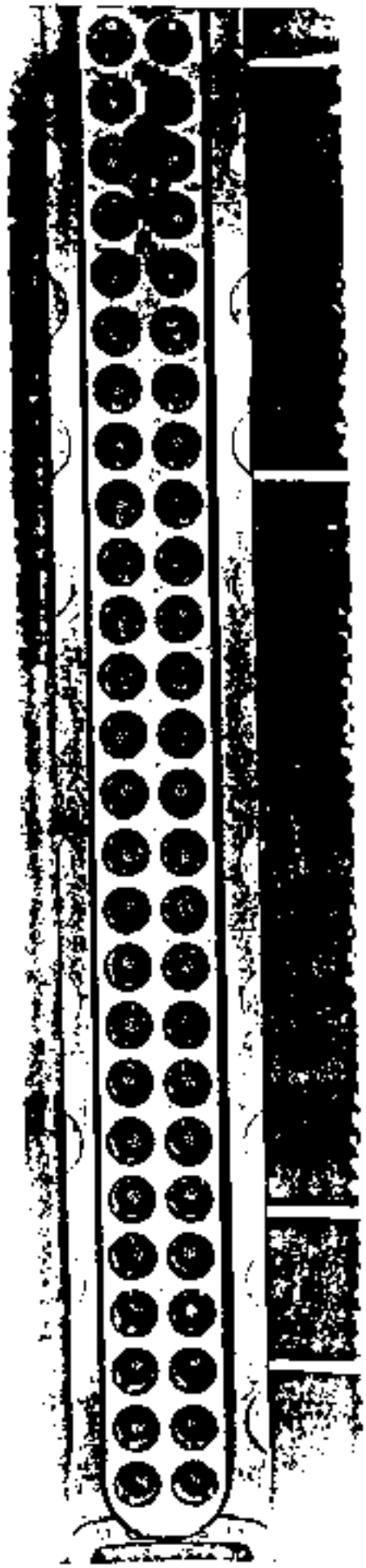


FIGURE 9

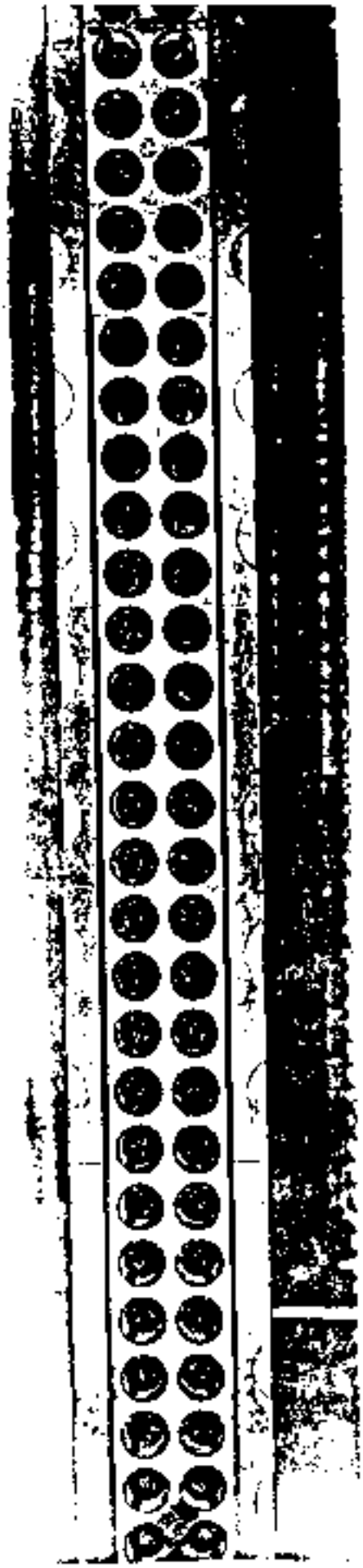


FIGURE 10

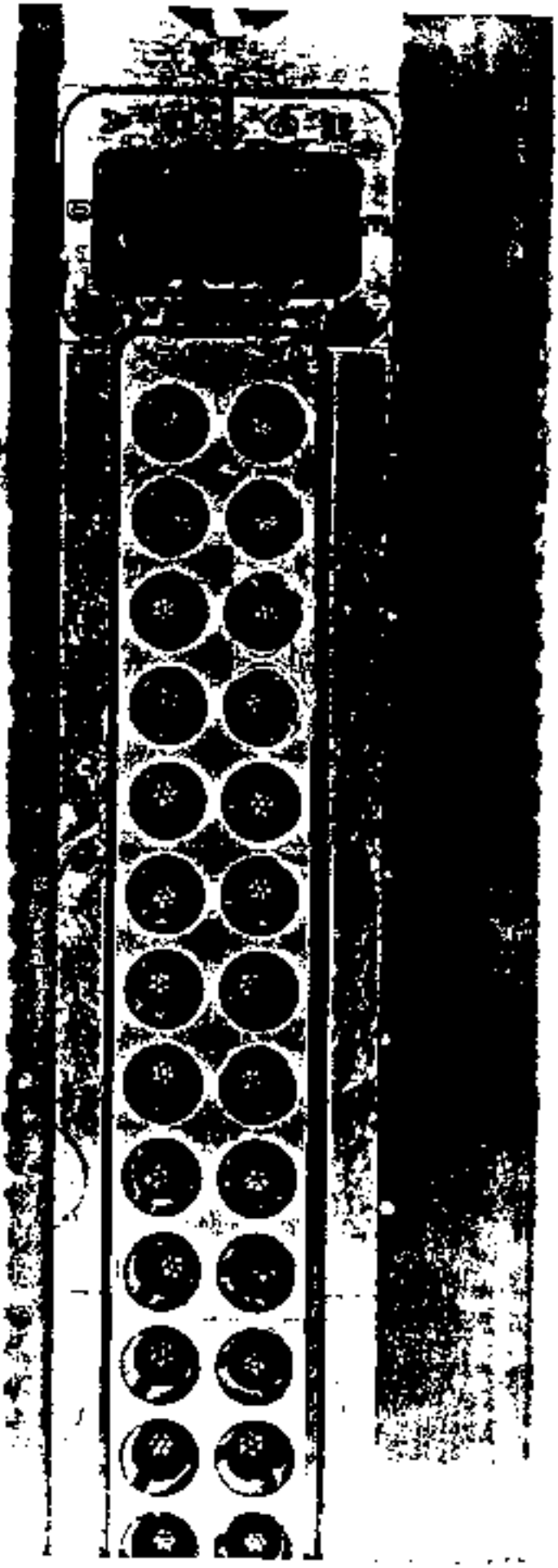


FIGURE 11

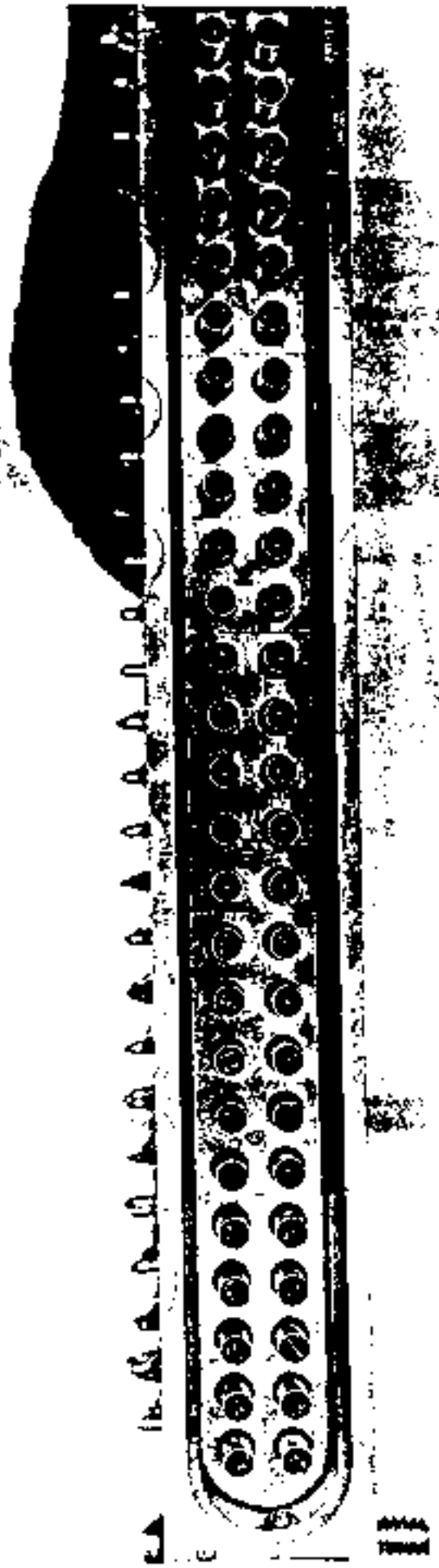


FIGURE 12